METHODS AND ARRANGEMENTS IN A TELECOMMUNICATIONS SYSTEM

FIELD OF INVENTION

The present invention relates to a method and devices for link adaptation in a cellular radio system.

DESCRIPTION OF RELATED ART

Usage of mobile communication equipment for transmission of digital data rather than speech has become increasingly popular among consumers. The ability to send and receive electronic mail and to use a web browser to obtain world-wide-web access is frequently discussed among services that will be used more and more in wireless communication systems. In response to this, mobile communication system designers search for ways to efficiently transfer data information to and from mobile users. Especially, it is desirable to be able to send data having as high data rate as the instantaneous radio channel quality permits.

In a mobile telecommunication system, the quality of the radio channel depends on a wide range of radio conditions including the distance between a receiver, e.g. a mobile station, and a transmitter, e.g. a base station, interference from other transmitters in the neighborhood, shadowing, short term fading, etc. As the radio conditions can be rapidly varying for each considered transmitter-to-receiver link, the radio channel quality for a transmitter-to-receiver link may consequently vary rapidly. If the radio channel quality is high, the transmitter may exploit this fact to transmit to the receiver at a higher data rate by adjusting the transmission parameters, e.g. reduce the amount of error protection, i.e. redundancy, or use higher order modulation. Similarly, if the radio channel quality is low, the transmission parameters may need to be adjusted to ensure reliable reception of the transmitted information having

a lower data rate. Modifying the transmission parameters in accordance with the radio channel quality variations is often termed "link adaptation" and allows the overall performance of the system to be significantly improved. Link adaptation can be accomplished by, e.g. changing the modulation and/or channel coding scheme (MCS). Different modulation and coding schemes can be provided through different modulation techniques, code rates, and puncturing schemes. Other means to accomplish link adaptation is also possible.

In order to implement link adaptation, information about the current radio channel quality is needed at the transmitter end. This can be provided by letting the receiver estimate the radio channel quality and feed this information back to the transmitter. Naturally, this requires the possibility for the receiver to estimate the radio channel quality and means for feeding back this information to the transmitter. The radio channel quality can be estimated in a number of different ways. The receiver may e.g. estimate the received signal-to-interference ratio, by measuring the received signal strength of a signal transmitted at a known constant power, such as a pilot signal, and the overall interference.

One interesting application of link adaptation is for a downlink shared channel (DSCH) in a CDMA-based system. The downlink shared channel in a CDMA system is a code or set of codes shared by several users in, among other techniques, a time multiplexed fashion. Each of the users sharing the DSCH is also allocated a downlink dedicated physical channel (DPCH) which is power controlled. In existing systems, all the dedicated physical channels are code multiplexed with the DSCH. A man in the art understands that other means of multiplexing may be used in the same way. Although this disclosure is directed towards WCDMA, the idea is general and can be applied to other cellular systems as well, e.g. various evolutions of IS95 and cdma2000.

In systems using conventional link adaptation (LA), the mobile station estimates the instantaneous quality of the radio channel. Based on the quality estimate, the mobile station transmits a request for an appropriate modulation and/or coding scheme to the base station. Alternatively, the mobile station reports the quality estimate to the base station. Based on this report, the base station then decides on the modulation and coding scheme used to communicate with the mobile station. It should be noted that the mobile station cannot determine the instantaneous radio channel quality from the above mentioned downlink dedicated physical channel as it is power controlled and, hence, ideally received at an almost constant signal-to-interference ratio regardless of the radio channel quality.

Generally, a base station is considered having a downlink shared channel (DSCH), possibly non-power controlled, used by several users for data transmission in a primarily time-multiplexed fashion. Additionally, a power controlled downlink dedicated physical channel (DPCH) is associated with each active mobile station sharing the DSCH and is used for transmitting control information to the mobile station. In existing systems, link adaptation of the DSCH in such a system is accomplished by letting the mobile station (MS) estimate the radio channel quality based on the received signal-to-interference ratio of a non-power-controlled common pilot signal broadcast by the base station and report this estimated quality, or a function thereof, back to the base station. The base station uses this feedback information to adjust the modulation and coding scheme (MCS) on the downlink shared channel to suit the current radio channel quality. This approach requires feeding information about the estimated radio channel quality from the mobile station back to the base station in addition to the power control commands already transmitted from the mobile station to the base station.

Power control for the downlink dedicated physical channel (DPCH) is typically accomplished by the mobile station

regularly measuring the received signal-to-interference ratio on the DPCH, comparing with a threshold, and sending up/down commands back to the base station, which adjusts the transmit power of the DPCH in accordance with these commands. Hence, the received signal-to-interference ratio on the DPCH is ideally kept constant.

According to other methods, the instantaneous transmit power of the DPCH is set by the transmitter based on some parameters in the base station indicating the downlink channel quality. A man skilled in the art understands that other means for setting the instantaneous power DPCH, either alone or in combination with the method disclosed above, may be used.

The patent document US-5946356 describes a system having fundamental and supplemental channels used for control and information transmission, respectively. As US-5946356 focuses on the cdma2000 standard, the terminology is the one used within the cdma2000 community. The main objective of US-5946356 is to provide a method and arrangement for allocating a fundamental channel only when a supplemental channel is available in order to avoid waste of precious resources on a fundamental channel, which is not used due to the lack of an available supplemental channel. A fundamental channel is assigned shortly prior to supplemental channel availability, reducing the amount of time a remote unit utilizes a fundamental channel and increasing the number of channels available to the system. Initialization of those channels is also discussed. In US-5946356 a method for initial power control of the fundamental channel being used for control information transmission, and a method for using the fundamental channel to set the appropriate power level for the supplemental channel being used for information transmission is also disclosed. Furthermore, in US-5946356 a system is disclosed having a fixed relation between the output power for the supplemental channel and the associated fundamental channel. US-5946356 is concerned with setting the power level of the supplemental channel based on the power level on the fundamental

channel and is not concerned with changing the modulation and coding scheme according with the channel quality. Thus, US-5946356 does not discuss problems related to link adaptation.

US-5,722,051 assigned to Lucent Technologies Inc discloses a dynamic combined power control and forward error correction control (FEC) technique for mobile radio systems, which is claimed to reduce the power consumed by wireless transmitters and increase the number of simultaneous connections which may be supported thereby. Individual transmitter-receiver pairs may adaptively determine the minimal power and FEC required to satisfy specified quality-of-service (QoS) constraints. I.e. US-5722051 describes a technique for setting the power level and coding scheme for a set of data to be transmitted based on parameters received from the receiver. These parameters are computed by the receiver based on a previously received set of data from the transmitter. Generally speaking, methods for controlling the coding scheme and power level based on explicit feedback information from the receiver are well known for a person skilled in the art, as disclosed above. In US-5,722,051, the benefits of letting the receiver directly control the transmitted power on the downlink shared channel and indirectly the modulation and coding scheme on the dedicated physical channel are neither disclosed nor discussed.

WO 95/15033, assigned to Thomson Consumer Electronics, Inc., is related to the field of digital satellite communication systems, and more particularly to error correcting apparatus in a receiver of such a system. WO 95/15033 describes one possibility of changing the coding rate of a transmitted signal based on the transmitted power of the same signal. WO 95/15033 is concerned with the problem of matching the amount of redundancy added by error correction coding to the different transmitted power levels used by a satellite on the channel which transmits the information. Thus, WO 95/15033 does not consider problems related to link adaptation.

US-5828695, assigned to British Telecommunications, describes a system varying the QAM modulation scheme used in the transmitter part of a transceiver based on the received signal strength measured by the receiver in the same transceiver. Thus, US-5828695 does not consider problems related to link adaptation.

SUMMARY OF THE INVENTION

A problem with proposed and/or existing systems using link adaptation is that the link adaptation relies on explicit uplink signaling related to the downlink radio channel quality, i.e. it increases the amount of data to be transmitted from the mobile station to the base station.

Another problem is encountered if adaptive antennas are used, where user data on the Downlink Shared Channel (DSCH) is to be transmitted in narrow beams covering only a part of the cell. In this case, it can be difficult, or even impossible, for the mobile station to estimate the radio channel quality related to the DSCH based on a broadcast common pilot signal since the broadcast common pilot signal will encounter a different radio conditions compared to the non-broadcast DSCH transmitted through the adaptive antenna. The radio channel quality estimated from the broadcast common pilot signal will thus be different from the radio channel quality experienced by DSCH transmission within a narrow beam.

The inventive solution of the problem is based on letting the instantaneous power allocated at the transmitter for the closed loop power controlled downlink dedicated physical channel (DPCH) control the modulation and/or coding scheme of the downlink shared channel (DSCH). The transmitted DSCH power should be used rather than the received DPCH power as the DPCH is power controlled and thus the signal-to-interference ratio at the receiver is, more or less, constant, giving no information about the varying radio channel quality. It should be noted that a further reason for not using the received DPCH

power is that this would not solve the first problem with the existing methods, i.e. it would require feedback signaling from the mobile station to the base station.

A method and arrangement according to the invention selects the modulation and coding scheme MCS on a non-power-controlled downlink shared channel (DSCH) based on the amount of transmit power allocated to the downlink dedicated physical channel (DPCH) corresponding to the mobile station currently using the DSCH. Each mobile station in the system that takes part in sharing the DSCH has access to one associated DPCH. The DSCH is shared between the users in some way, e.g. in a time division fashion, wherein one user at a time uses the resources, and is not power controlled by any of the users. In a preferred embodiment, the procedure of selecting an appropriate modulation and coding scheme MCS for the DSCH as a function of the power level on the DPCH associated with the user currently using the DSCH is repeated each time the transmitted power of the associated DPCH changes.

In a preferred embodiment of the invention, the transmitted power used by the downlink shared channel (DSCH) is constant over time and the modulation and coding scheme MCS used at each time instant is given by the power used by another power controlled downlink dedicated physical channel (DPCH), namely the DPCH associated with the user currently assigned the downlink shared channel.

According to a preferred embodiment, the inventive method is provided by means of a computer program product directly loadable into the internal memory of a digital computer, said computer being located or connected to the base station.

A purpose of the inventive system and arrangement is to facilitate the selection of a suitable modulation and/or coding scheme of a common downlink channel, the system being provided or not provided with adaptive antennas, and without introducing any new feedback information or other overhead.

A further purpose of the inventive system and arrangement is to provide link adaptation without having to transmit explicit link adaptation information from the mobile station to the base station

An advantage of the inventive system and arrangement is that they facilitate the selection of a suitable modulation and/or coding scheme of a common downlink channel, the system being provided or not provided with adaptive antennas, and without introducing any new feedback information or other overhead.

A further advantage of the inventive system and arrangement is that no explicit link adaptation information has to be transmitted from the mobile station to the base station, i.e. there is no need for changing the format of the reverse link compared to current standards.

The term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram illustrating a communication system for which the invention applies.

Figure 2 is a flowchart illustrating a method according to the invention.

Figure 3 is a diagram illustrating an example of how the MCS used by different users on the downlink shared channel (DSCH) at different times are controlled by the power used by the dedicated physical channel (DPCH).

Figure 4 is a flowchart illustrating an example of the mapping procedure.

Figure 5 is a flowchart illustrating a method according to the invention involving several users.

The invention will now be described in more detail with reference to preferred exemplifying embodiments thereof and also with reference to the accompanying drawings.

DETAILED DESCRIPTION

In figure 1, a communication system using three channels is illustrated in more details. The naming of the channels is taken from WCDMA and other names might be used for other similar systems in which the invention can be applied. The Downlink Shared Channel (DSCH) is a common channel for transmitting information from a base station (BS) 110 to a mobile station (MS) 120, the channel being shared by several users, e.g. in a time division fashion, code division fashion, or combinations thereof. In an inventive system, this channel is not power controlled, but uses a varying modulation and coding scheme (MCS) to adapt to the rapidly changing radio channel quality. The Downlink Dedicated Physical Channel (DPCH) is a dedicated channel (one per user) for the transmission of information from the base station to the mobile stations, typically carrying, among other things, control information. It is power controlled and, hence, is ideally received at a constant signal-to-interference ratio at the mobile station. Power Control (PC) commands are sent from each mobile station to the base station on a separate uplink in order to adjust the DPCH transmit power so that a fixed signal-to-interference

ratio is maintained for DPCH at the mobile station. When the received signal-to-interference ratio lies below a certain threshold, the mobile station instructs the base station to increase the DPCH transmit power. Similarly, if the received signal-to-interference ratio lies above the threshold, the mobile station sends PC commands to the base station so that the DPCH transmit power is decreased.

In the method and system according to the invention, the modulation and coding scheme used on the DSCH is set by the power used by the base station for the DPCH. If the amount of power used for the DPCH corresponding to the mobile station currently using the DSCH is high, the radio channel, i.e. the downlink from the base station to the mobile station, is presumably of low quality and a modulation and coding scheme suitable for this kind of channel should be used. If the amount of power used for the DPCH by the base station is low, the radio channel is of high quality and a modulation and coding scheme supporting a high rate at the cost of being more sensitive to channel impairments is suitable. By using this scheme, explicit feedback from the receiver to select the modulation and coding scheme of the DSCH is avoided. Furthermore, adaptive antennas can be used on the link adapted DSCH, which is not possible if the radio channel quality is estimated based on mobile station measurements on a received common pilot broadcast over the entire cell.

Fig. 2 is a flowchart illustrating a method according to the invention. The method disclosed in connection with fig. 2 is performed at the base station. In block 210 the base station receives the power control (PC) commands from the mobile station. Then, in block 220 the transmission power for the dedicated physical channel DPCH is adjusted according to the PC commands received in block 210. Thereafter, in block 230, the transmit power used for the dedicated physical channel is mapped into a suitable modulation and coding scheme (MCS) for the downlink shared channel (DSCH). It should be noted that the

MCS is only used on DSCH if the user of this DPCH is allocated to the DSCH. Finally, in block 240, data is transmitted on the DSCH using the previously selected modulation and/or coding scheme. At the same time, control, and possibly other information is transmitted on the DPCH using any non-changing modulation technique agreed upon, such as QPSK. The procedure according to the blocks 210-240 are repeated with regular intervals.

Compared to conventional systems, e.g. systems according to the WCDMA standard, the method according to fig. 2 is new with respect to two features. First, the inventive idea resides in the mapping of the power used in the dedicated physical channel into a suitable modulation and coding scheme. Secondly, in the method according to the invention, a varying modulation coding scheme is used on the downlink shared channel. The second feature is well known, but currently not used in systems according to the WCDMA standard.

The mapping between the power level P_{DPCH} of the downlink dedicated physical channel (DPCH) and the modulation and coding scheme MCS chosen for the downlink shared channel DSCH can e.g. be implemented in form a table or a similar arrangement, see e.g. Table 1.

Table 1

P_{DPCH} power range	MCS for DSCH
$P_{DPCH} \geq P_1$	$MCS = MCS_1$
$P_1 > P_{DPCH} \geq P_2$	$MCS = MCS_2$
$P_2 > P_{DPCH} \geq P_3$	$MCS = MCS_3$
$P_3 > P_{DPCH} \geq P_4$	$MCS = MCS_4$
$P_4 > P_{DPCH} \geq P_5$	$MCS = MCS_5$
$P_5 > P_{DPCH} \geq P_6$	$MCS = MCS_6$
$P_6 > P_{DPCH} \geq P_7$	$MCS = MCS_7$
$P_7 > P_{DPCH}$	$MCS = MCS_8$

The mapping between the power level P_{DPCH} of the DPCH and the modulation and coding scheme MCS chosen for the DSCH as e.g. implemented by a table like Table 1 can be either static or dynamic. In the static case, the power levels Pi in Table 1 are typically chosen in advance by the operator. An example of a static mapping is shown in Table 2.

Table 2

P_{DPCH} power range (in percent of full power)	MCS	Code rate	Modulation
$P_{DPCH} \geq P_1 = 60\%$	MCS_1	1/2	QPSK
$60\% = P_1 > P_{DPCH} \geq P_2 = 50\%$	MCS_2	3/4	QPSK
$50\% = P_2 > P_{DPCH} \geq P_3 = 30\%$	MCS_3	1/2	8PSK
$30\% = P_3 > P_{DPCH} \geq P_4 = 20\%$	MCS_4	3/4	8PSK
$20\% = P_4 > P_{DPCH} \geq P_5 = 15\%$	MCS_5	1/2	16QAM
$15\% = P_5 > P_{DPCH} \geq P_6 = 10\%$	MCS_6	3/4	16QAM
$10\% = P_6 > P_{DPCH} \geq P_7 = 5\%$	MCS_7	1/2	64QAM
$5\% = P_7 > P_{DPCH}$	MCS_8	3/4	64QAM

In Table 2, PSK means Phase Shift Keying. QPSK means Quaternary Phase Shift Keying. QAM means Quadrature Amplitude Modulation. The integers 8, 16, and 64 indicate the amount of signaling alternatives.

Fig. 3 is a diagram showing an example of how the modulation and coding scheme MCS used by different users on the downlink shared channel DSCH at different times is controlled by the power used by the respective downlink dedicated physical channels (DPCH). In fig. 3, a case wherein three users share a DSCH is illustrated. In the example shown in fig. 3, different modulation and coding schemes, denoted MCS1 through MCS8, may be selected to be used by the DSCH. MCS8 denotes the modulation and coding scheme yielding the highest data rate but requiring the best radio channel quality. On the other hand, MCS1 results in a low data rate, but is robust to bad radio conditions. As is shown in fig. 3, the DSCH is transmitted at a constant power level, i.e. the channel is not power controlled by any of the

mobile stations. However, the dedicated physical channels are power controlled. The transmit power for each of the dedicated physical channels is thus adjusted in order to keep the received signal-to-interference ratio at the mobile unit constant.

In fig. 3 is shown that the scheduler has assigned the downlink shared channel (DSCH) to user 1 for some amount of time determined by the scheduling algorithm, for example one slot duration. The power used by user 1 on its associated dedicated physical control channel, DPCH1, is quite low, indicating good conditions on the link from the base station to the mobile station of user 1 and, hence, a fairly advanced modulation and coding scheme can be used (in the case MCS7). After some time, the scheduler has decided to assign the DSCH to user 2, and since the mobile unit of user 2 also consumes very little power on its associated DPCH2, and therefore is provided with good channel properties, MCS8 is chosen for the DSCH resulting in the highest bit rate. At a later stage, the DSCH is still assigned to user 2 by the scheduler, but the channel quality has degraded and consequently, the transmitted power on DPCH2 is increased, for example due to a fading dip. A lower rate MCS, in this case MCS6 will therefore be used. The procedure of selecting an appropriate modulation and coding scheme for the DSCH depending on the power level on the dedicated physical channel associated with the user currently using the DSCH is repeated as times evolves, which is clearly seen in fig. 3.

According to the invention, the user given the downlink shared channel (DSCH) at any given time is determined by a scheduling algorithm operating according to some set of rules. One simple scheduling algorithm could be to cyclically assign the DSCH to the mobile stations in a round robin fashion, but other, more advanced algorithms are also possible.

In a case where the downlink dedicated physical channel is transmitted simultaneously from two, or more, separate base stations, so called soft handover, the transmit power of the

DPCH is lower than in the case DPCH was only transmitted from the base station from which the Downlink Shared channel is transmitted. In this case, the DPCH transmit power will thus not necessarily provide the correct MCS. A solution to this problem is to multiply the DPCH power with a constant k, the constant k being a function of the number of base stations involved in the soft handover.

Fig. 4 is a flowchart illustrating an example dynamic updating of the mapping table in table 1. The flowchart in fig. 4 is thus an example of how to define the mapping process disclosed in block 230 in fig. 2. Fig. 4 illustrates a dynamic scheme, the mapping being changed as a function of some retransmission requests for the data blocks transmitted over the downlink shared channel. For each retransmission request, see block 510, from a certain user, the flow goes to block 520 and the transmitter decreases the power levels Pi required to select a certain modulation and coding scheme, making the mapping more robust and conservative. Similarly, if no retransmission request is made for a data block, the flow goes to block 530 and the transmitter interprets this as the mapping being too conservative and raises the thresholds Pi for the different modulation and coding schemes. For the next data block, the procedure disclosed in fig. 4 is iterated.

It should be noted that an adaptive/dynamic scheme might be influenced by a plurality of parameters, e.g. the amount of data in the transmission, the amount of restrictions on retransmission.

Fig 5a and b illustrates the inventive method in a system having at least two users. First, in block 610 fig. 5a, the DPCH transmit power is adjusted for each user. In fig. 5b, the adjustment of the DPCH transmit power is disclosed in more detail. In block 620, it is determined which user is to use the downlink shared channel (DSCH) within a certain time interval. Then, in block 630, the DPCH power is mapped for a selected user

into a suitable MCS for the DSCH. Finally, in block 640, data is transmitted on the DSCH.

Fig. 5b is a flowchart illustrating the adjustment process of block 610 in more detail. In block 612, the PC command transmitted form the mobile station is received by the base station. In block 613, the PC command is interpreted and it is determined from the PC command whether the DPCH power is to be increased or decreased. When the DPCH power is to be increased the flow goes to block 614. When the DPCH power is to be decreased, the flow goes to block 616.